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COMPLETE SPECIFICATION

Improvements in or relating to Compression Stills and method of Continuous Distillation

I, KENNETH CLAUDE DEVEREUX HICKMAN, a citizen of the United States of America, of 136, Pelham Road, City of Rochester, State of New York, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to methods of and apparatus for compression distillation.

In accordance with the present invention, there is provided a compression still comprising at least one rotary heat exchange and phase separation barrier of high thermal conductivity having integral radially extending evaporating and condensing surfaces disposed in heat exchange relationship, a feed pipe for continuously supplying distilland to said evaporating surface, radially inwardly from the outer periphery thereof, at a rate in excess of that required to wet said evaporating surface, means for rotating said barrier at a speed producing centrifugal force sufficient to continuously spread and flow and maintain said distilland on said evaporating surface in a film substantially thinner than that attainable by gravitational flow with the same throughput, means for collecting residue centrifugally discharged from said evaporating surface, means for compressing vapor evolved from the evaporating surface, and means for directing said compressed vapor into contact with the condensing surface upon which surface the vapor condenses and the condensate is maintained in a film substantially thinner than that attainable by gravitational flow with the same throughput, said condensate being removed from the condensing surface through rotation of said barrier.

In accordance with the present invention, there is provided a method of continuous distillation which comprises applying centrifugal force of a magnitude many times greater than the force of gravity to distilland so as to continuously distribute and flow and maintain distilland on the evaporating surface of a heat exchanger in a film substantially thinner than can be secured by a flow of such distilland of the same throughput on the same surface flowing under the influence of a force of the order of gravity alone, continuously evolving vapour from said flowing film and separating the residue therefrom, collecting said residue out of contact with said flowing film, withdrawing and compressing said vapor and contacting such compressed vapour with a condensing surface on the opposite side of said heat exchanger so as to condense said vapour thereon, whereby heat is transferred to said evaporating surface and thence to said film of distilland to effect the evolution of vapour therefrom, and separating condensate from said condensing surface as it condenses thereon so as to prevent the accumulation of such condensate on said condensing surface.

Compression stills in common use generally employ a conventional boiler and a tubular condenser immersed in the boiling liquid, and the large body of distilland presents a relatively large resistance to the evolution of vapor. In addition the undistilled residue contaminates the distilland. These stills also require frequent cleaning to remove the accumulation of precipitate from the heat exchanger surfaces.

Generally the difference in pressure between the evaporating and condensing sides of the heat exchanger is about three pounds, and the difference in temperature of the distilland and distillate is about 12° F. This difference of temperature or heat drop between the evaporator and condenser is referred to as "*dt*". The total process of evaporation and condensation has been described by Langmuir *et al* as occurring in a number of readily recognizable steps, each of which is assigned a resistance. These resistances are reciprocals of rates of process and are additive arithmetically, [illegible] R [illegible] Each resistance is associated with a temperature drop [illegible] Such resistances comprise a resistance r^1 to the flow of vapor through the conduits, a resistance r^2 to the flow of heat through the evaporating liquid, a resistance r^3 to the flow of heat

through the heat exchange barrier, a resistance r^4 to the flow of heat through the distillate, and a resistance r^5 to the detachment of vapor from the surface of the evaporating liquid.

While compression stills employing gravity falling films on both stationary and rotary heat exchange surfaces have been suggested, as for example in British Patent No. 163,793, such suggestions have not so far as I know significantly increased the efficiency of this type of still, and the heat pressure drop *dt* is still much greater than intrinsically required. This necessitates the use of positive displacement pumps or expensive turbo compressors. In addition, the scale formation on such heat exchange surfaces seriously and rapidly impairs the efficiency of the heat transfer between such surfaces and the fluids in contact therewith.

It is clear that by diminishing the body of distilland and/or distillate to nearly the vanishing point, so that the obstructive film is substantially lessened, resistances r^2, r^4 and r^5 are greatly diminished and both the heat drop and the pressure drop can be limited so materially as to create a useful compression distillation method and apparatus which are substantialy more efficient than those heretofore contemplated.

A principal object of this invention, therefore, is to provide a new and highly efficient compression distillation method and apparatus in which the resistance to the flow of heat through the evaporating and/or condensing films, and the resistance to separation of the vapor from the distilland are greatly reduced.

Several embodiments of the invention will now be described in conjunction with the accompanying drawings, of which there are three sheets and wherein:—

Fig. 1 is a schematic sectional view of a compression still embodying the invention and utilizing a rotary disk type of heat exchange and phase separation barrier;

Fig. 2 is a fragmentary sectional view on the line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 1 but showing a modified type of compression stage;

Fig. 4 is a view similar to Fig. 1 of a modified form of the invention and employing a tubular type of heat exchange and phase separation barrier;

Fig. 5 is a schematic sectional view of a compression still illustrating a modified form of the invention employing heat exchange and phase separation barriers in the form of paired conical members;

Fig. 6 is a schematic view of a further modified form of the invention employing a rotary heat exchange and phase separation barrier in the form of a corrugated tubular member;

Fig. 7 is a sectional view taken along line 7—7 of Fig. 6;

Fig. 8 is a modification of Fig. 6 in which the discharge of distilland on to the evaporating surface is employed to effect the rotation of the heat exchange barrier, and

Fig. 9 is a sectional view taken along the line 9—9 of Fig. 8.

As illustrated in Figs. 1 and 2, a compression still embodying my invention comprises in general a rotary phase separation barrier 20 of high thermal conductivity forming a heat exchanger, a distilland feed pipe 22, a vapor compressor 24, a discharge conduit 26 for the distillate, and a discharge conduit 28 for the undistilled residue.

The barrier 20 as illustrated comprises a disk-shaped conical element, the hub 30 of which is mounted on a drive shaft 32 for rotation therewith, the drive shaft 32 being journaled in bearing 34. A heat insulated casing 36 encloses the barrier 20 and forms with one side of the disk 20 an evaporating chamber or evaporator 38. The heat exchange surface 40 of the disk 20 exposed to the chamber 38 forms an evaporating surface, and the opposite face 42 of the disk or barrier 20 forms a condensing surface. The outer periphery of the disk 20 is made in the form of an annular trough or gutter 44 for collecting the undistilled or concentrated residue, and the end 46 of the discharge conduit 28 extends into said trough 44 and opens upstream so that upon rotation of the disk liquid contained in the trough 44 will be discharged through the conduit 28. The distilland feed pipe 22 as illustrated terminates adjacent the center of the evaporating surface 40 on the disk 20 and forms part of a means for continuously supplying and spreading and flowing distilland on the evaporating surface 40. Rotation of the barrier 20 at a sufficient speed will spread and flow distilland on the evaporating surface 40 in a film substantially thinner than can be secured by a flow of such distilland of the same throughput on the same surface under the influence of gravity alone. I contemplate rotating the barrier 20 at a speed such that the flowing film of distilland will be no thicker than a flow of such distilland of the same throughput on the same surface under the influence of a force at least ten times gravity, although satisfactory results may in some cases be obtained by employing slower speeds.

A brush 48 is mounted in the chamber 38 so that the bristles thereof engage or scrub the evaporating surface 40 upon the rotation of the disk 20, and suitable provisions (not shown) may be employed for moving the bristles of the brush 48 [illegible] contact with the surface 40. The brush 48 may optionally be utilized to dislodge precipitates, if any, from the surface 40. The casing 36 as illustrated is of cylindrical form and includes an integral back wall carrying the bearing 34 and a removable front cover 50.

The disk 20 has affixed thereto for rotation therewith an annular wall 52 having an opening 54 in its center and integrally connected

at its periphery by an annular wall 56 with the periphery of the disk 20. The condensing surface 42 of the disk, together with the peripheral wall 56 and the annular wall 52, form a condensing chamber 58 which is supplied with compressed vapor through the opening 54. The vapor compressor 24 which, as illustrated, comprises a series of blades 60 distributed about the periphery of the disk 20 and mounted thereon for rotation therewith, serves to withdraw vapor evolved by the flowing film of distilland on the evaporating surface 38 and to compress said vapor so that it will condense at a temperature above that at which it is evolved. The compressor blades 60 discharge such vapor through a series of volute blades 62 fixed on the periphery and back wall of the casing 36 and into a space 64 between the back wall of the casing and a partition 66 supported in spaced relation thereto by blades 62 and struts 68. The partition 66 is disposed closely adjacent to the wall 52 of the barrier and has an edge defining a central opening in line with the opening 54 in the wall 52. A running seal (not shown) is provided between the wall 52 and the partition 66 so as to separate the evaporator and condenser sides of the still.

The distillate discharge pipe 26 extends into the condenser chamber 58 and into close proximity with the inner surface of the peripheral wall 56, and has its end turned upstream so that condensed distillate will be discharged through the conduit 26. If necessary or if desired, conduits 26 and 28 may be arranged in heat exchange relation with the distilland feed pipe 22 so as to transfer heat from the concentrate and distillate to the distilland.

The shape of the condensing surface 42 separates condensate therefrom as it condenses so as to prevent the accumulation of condensate thereon, and the film of condensate will be thinner than can be secured by a flow of such condensate of the same throughput on the same surface under the influence of gravity alone, and in any event will be of a thickness of the same order of thickness as that of the distilland on the evaporating surface 40. The rotation of the condensing surface 42 will, in addition to centrifuging therefrom the condensate, also serve to further compress by centrifugal force the compressed vapor in the chamber 58 to promote the condensation thereof.

The compressed vapor is discharged by the compressor into intimate heat exchange relation with the condensing side of the barrier opposite the flowing film of distilland on the evaporating surface 40 so that the heat of condensation of the vapor on the condensing surface 42 will be transferred through the disk 20 and will promote the evolution of vapor from the flowing film on the evaporating side of the barrier. The rotation of the disk 20 at the speeds contemplated will also function to centrifuge the vapor as it evolves with respect to the flowing film on the surface 40. By greatly reducing the thickness of the films of distilland and distillate in accordance with my invention, the resistances r^3 and r^4 to the flow of heat through such films and the resistance r^5 to the detachment of vapor from the surface of the evaporating liquid will be greatly diminished as compared with known systems, thereby making possible a great increase in the efficiency of this compression distillation system.

In a preferred method of operation, a partial vacuum equal to the saturated pressure of distilland is maintained in the still by a pump (not shown), and the distillate and residue may in addition be withdrawn by suction pumps connected to the pipes 26 and 28, in which event the heat exchange between the liquid in the pipes 26, 28 and 22 may be dispensed with.

In operation, distilland supplied through the pipe 22 to the center of the rotating evaporating surface 40 will spread and flow in a thin film of the character heretofore referred to outwardly over the surface 40 and toward the gutter 44 where the undistilled residue will be collected and discharged through the pipe 28.

It will be appreciated that the rotational speeds required to give adequate spreading of the distilland are much less than those desired for accelerating and compressing the vapor. It it contemplated therefore that the compressor means comprising the fan blades 60 may be separated from the rotating barrier, as shown in Fig. 3 where the shaft 32 rotates slowly, for instance, at 500 r.p.m. In this modification the compressor comprises a frame or disk 146 carrying fan blades 147 and mounted on a second shaft 148 rotating in a bearing 149 on the casing cover 150. The double walled barrier and associated conductors are the same in this modification, but a stationary partition 151 is supported in the casing 136 and provided with a peripheral flange 152 which extends adjacent the compressor blades 147 to form a passageway 153 leading as before into the space between the barrier walls. In this construction the compressor shaft 148 may be rotated at say 3600 r.p.m. so as to increase the compressing function. The construction and operation of this modification are otherwise as previously described.

In the modification shown in Fig. 4, the barrier is of generally conical shape, and I contemplate that the [illegible] may vary within wide limits from almost 180° to almost 0°, and in the latter event the barrier would be more tubular than as illustrated in Fig. 4. In Fig. 4 the barrier comprises a thin outer concave wall 254 of high thermal conductivity and a connected wall 255 supported therefrom as shown to leave a condensing

chamber 256 therebetween, the barrier being fixed on the outer end of a shaft 257 rotatably supported in a bearing 258 extending through the outlet conduit 259 of a compressor or compressor fan 260 of any known or suitable construction having its intake 261 communicating with the interior of the casing 250 as shown. The outlet conduit 259 of the compressor communicates with the chamber 256 and has a running seal with the wall 255 so as to separate the condensing chamber 256 from the evaporating chamber 252 in which the barrier rotates.

The compressor 260 withdraws vapor from the interior of the casing 250, compresses the same, and discharges it into the condensing chamber 256. A conductor 263 for distillate has an angularly turned end located in the peripheral portion of the space 256 and is led outwardly through the conduit 259 and thence to a vacuum withdrawal pump and/or heat exchange unit (not shown). Distilland fed through the feed pipe 264 is discharged adjacent the center of the barrier wall 254 and distributed thereover by centrifugal force upon rotation of the barrier by the shaft 257. The thickness of the film of distilland on the evaporating surface of the barrier 254 will, of course, depend upon the rate of feed and the speed of rotation of the barrier, and in order to utilize the invention herein disclosed the barrier is rotated at a speed so that the distilland will flow in a film substantially thinner than can be secured by a flow of such distilland of the same throughput on the same surface under the influence of gravity alone, and as described in connection with the previous modification.

The undistilled residue is slung off the outer periphery of the barrier into the casing 250 and withdrawn, if desired, under suction through a conduit 266. Conduit 266 may, if desired, be passed along with the distillate conduit 263 in heat exchange relation with the distilland feed pipe 264. The construction and operation of the modification shown in Fig. 4 are otherwise the same as those of the modifications previously described.

In the foregoing modifications the evaporating surface and the uncompressed vapor are directly exposed to the outer casing of the still, while the compressed vapor is contained within a secondary condensing chamber. Fig. 5 shows a modification where this situation is reversed and vapor is generated within a closed rotating vessel and passed therefrom through a compressor to the outer container where it is condensed on the outside of the rotating barrier and immediately flung therefrom, leaving only the thinnest film of distillate on the condensing surface to obstruct the flow of heat to the heat exchanger.

In Fig. 5 a casing 367 including a cover 368 encloses a pair of rotary paired cones 370. A centrifugal vapor compressor 372 and an electric motor 374 for driving the same are supported on the cover 368. The rotary paired cones 370 form a rotary phase separation barrier and heat exchanger of high thermal conductivity and at one end are rotatably supported by the bearing and seal assembly 376 and at the other end by the bearing and seal assembly 378. Distilland is supplied through a feed pipe 380 under the control of a valve 382 and through a degasser 384, and feed pipe 386 which extends through the bearing and seal assembly 376 to the nozzles 388 which discharge the distilland at the center of the rotating evaporating surfaces 390 of the barrier 370.

The barrier 370 is rotated at such a speed as to cause the distilland discharged by the nozzles 388 to spread and flow on the evaporating surfaces 390 in films substantially as thin as can be secured by a flow of such distilland of the same throughput on the same surface under the influence of a force at least ten times gravity. The vapor evolved from the flowing films of distilland on the surfaces 390 is withdrawn through the conduit 392 by the centrifugal compressor 372 which compresses such vapor and discharges it through the conduit 394 into the casing 367. The compressed vapor is brought into intimate heat exchange relationship with the outer condensing surface of the barrier 370 and condensed thereon, the heat of condensation thereof being transferred by the barrier to the flowing film on the evaporating surfaces 390 so as to promote the evolution of vapor therefrom.

The rotation of the barrier 370 separates condensate from the condensing surfaces so as to prevent the accumulation of condensate on the condensing surfaces in a layer thicker than can be secured by a flow of such condensate of the same throughput on the same surface under the influence of gravity alone. The condensate may be withdrawn from the casing through a pipe 393 under the influence of suction pump 394. The undistilled residue is collected in the troughs or gutters 396 and removed therefrom by the condensate discharge pipes 398, the ends of which project into the troughs 396 and face upstream so that the liquid residue will be forcibly discharged through the pipes 398 which pass out through the bearing and seal assembly 376. A suction pump 400 may have its intake connected to the upper end of the de-gasser 384 and to the [illegible] pressure therein.

The barrier 370 is connected by a spider 402 to a rotary drive shaft 404 which passes through the bearing and seal assembly 376 to any suitable driving means for rotating the barrier at the desired speed. The de-gasser 384 and the casing 367 may be exhausted of residual air by the pump 400 so that the still will operate at the temperature of the distil-

land supplied through the feed pipes 386.

The foregoing modifications show smooth rotating heat exchanger surfaces varying in contour from nearly flat plates through a cone or parabola to a nearly cylindrical tube. Obviously other surfaces may be employed which possess the characteristic of extending the area of heat exchange surface which can be accommodated in a given volume while providing spreading and flowing of distilland and distillate in films substantially thinner than can be secured by gravity with the same throughput.

Another form of such an extended surface is shown in Fig. 6 where the rotary heat exchange and phase separation barrier 450 is constructed of corrugated sheet metal fastened hermetically between end plates 452, the same being rotatably supported upon a drive shaft 454 journaled in bearings 456 and 458 mounted on the casing 460. The casing 460 houses the barrier 450. One of the end plates 452 is internally formed to provide a hollow peripheral gutter 462 to receive and collect undistilled residue through the holes 464 which communicate with the evaporating chamber 466, the holes 464 being located inside the tips of the corrugations of the rotary heat exchange barrier 450. A pickup tube 468 conveys residue from the gutter 462 through the bearing and seal assembly 458 to the exterior of the casing 460.

A compressor fan 470 driven from the shaft 454 withdraws vapor from the evaporating chamber 466 inside of the barrier 450 and compresses the same, and the compressed vapor is then discharged into the casing 460 on the outside of the barrier 450 through the conduit 472. A feed pipe 474 extends into the casing 460 through the bearing and seal assembly 458, and distilland is sprayed inside the barrier in two even longitudinally disposed sprays or sheets 476 and 478, one of such sets of sprays being designed to impinge on one set of the internal surfaces of the rotary barrier 450 while the other set of sprays is designed to discharge liquid on to the other set of internal surfaces of the rotor 450 during rotation thereof. The shaft 454 extends outside of the casing 460 through the bearing and seal assembly 458 where it may be connected with any suitable driving means.

The rotary barrier 450 is rotated at such speed so as to spread and flow the distilland on the internal evaporating surfaces thereof, and the vapor is withdrawn from the evaporating chamber 466 by the rotary fan 470 of the compressor through the conduit 480 which has a running seal with the barrier 450 so as to separate the evaporating chamber internally thereof from the condenser chamber externally thereof. Distillate is flung off the outer surfaces of the barrier 450 into the chamber 460, and such condensate may be withdrawn from the condensing chamber in a manner previously described in the other modifications. This construction offers a rigid inexpensive assembly of relatively large heat exchange area. Any lessening of the evenness of spreading of the distilland as compared with the previous modifications is compensated for by the larger available area of heat exchange surface.

A further modification is shown in Figs. 8 and 9 wherein the corrugated heat exchanger barrier is constructed with curved volutes 500 which are rotated by powerful sprays of disthilland supplied by an external liquid pump (not shown) through a pipe 502. In this case the evaporating chamber and surfaces are on the outside of the barrier 504 and the condensing surfaces and chamber are on the inside. The barrier 504 is mounted for rotation on a shaft 506 journaled in bearings in the casing 508. A compressor 510 withdraws vapor from the evaporating chamber 512 through the conduit 514 and discharges the same into the interior of the barrier 504 where it condenses on the inner surfaces thereof. A condensate discharge pipe 516 is arranged to withdraw condensate from an annular trough formed in one or both of the end plates 518 of the barrier in the same manner as the undistilled residue is removed from the barrier as shown in Fig. 7.

The construction of Figs. 8 and 9 is very similar to that of Figs. 6 and 7 except for the manner in which the rotary heat exchanger barrier is driven and for the fact that the condensing surface in Figs. 8 and 9 is on the inside and the evaporating surface in Figs. 8 and 9 is on the outside, wherein in Figs. 6 and 7 these surfaces are reversed.

It is contemplated that the modifications shown in Figs. 6, 7, 8 and 9 may be operated in the same way as those previously discussed, and it is further contemplated in any of the modifications, if desired, that the condensing surface may be used as an evaporating surface and *vice versa*, although it is obvious that this reversal of the arrangement will not necessarily be advantageous in all cases.

The construction shown in Figs. 8 and 9 is particularly adapted for the concentration of slurries and fruit juices, since any suspended matter in the feed is flung off the rotor. Also, the construction is partly self-pumping as regards vapor and may be made entirely so by driving the rotary barrier at high speed by an external driving means. When the vapor is centrifuged off the outside and centrifugally compressed on the inside, as in this modification, it may in some applications be possible [illegible] compressor 510.

[illegible] the modifications it is necessary to supply some heat to promote the evolution of vapor initially, and to reduce thermal losses insulation may be appropriately applied to the still.

It has been calculated by the known Langmuir-Knudsen equation that the gross rate of evaporation of water at 100° C. is 97.7 litres per second per square meter of exposed liquid surface. When no steam is withdrawn, the same quantity of vapor condenses each second, and vapor and liquid are said to be in equilibrium. Suppose, now, that $^1/_{10}$ litre of water is withdrawn each second in the form of steam, then the equilibrium will be disturbed by 1 part in 1000. The evaporating vapor pressure will be 760 mm Hg and the condensing pressure 759.24 mm. The difference in boiling points corresponding with these two pressures is less than 2/100° C. If we allow 2° C. as temperature drop through the separating wall and liquid films in the stills of this invention, as their thinness and extended area permit us to do, the total temperature difference at the rate cited is less than 2.1° C.

The more useful situation, however, is when a relatively strong salt solution is evaporated and the steam is condensed to substantially pure water. As a useful simplification, it will be considered that the dissolved solids of sea water lower the vapor pressure of steam at 100° by 4.3 mm. for each 1% dissolved. To concentrate sea water from approximately 3% salt to 15% salt will require a minimum pressure difference between evaporator and condenser of 65+2 mm Hg, or 36″ of water, or 1.7 lbs. gauge. At the other extreme, brackish water containing ½ of 1% of solids will require 2.2+2.1=4.3 mm Hg, or 2.33 inches of water pressure difference. The construction according to my invention, while embodying real economies of first cost and low pressure differential for the distillation of heavy salt solutions, shows its greatest relative economy in purifying brackish waters of moderate salt content. The pressure differences required by other compression stills are much greater because of the construction of still and the difficulty of detaching vapor from the surface of the distilland.

In a compression still there are thus two drops in pressure to be considered, one due to the intrinsic difference in vapor pressure of pure water and concentrated salt solution, the other due to difficulty of detaching vapor from the distilland. Where high pressure differentials are used, as in connection with conventional boilers, high velocities of vapor are automatically involved, and, if the vapor is produced by ebuliative boiling, splashings will be entrained and discharged from the boiler. Where, as in my invention, a relatively large area is exposed for evaporation, and ebuliative boiling is absent, entrainment is substantially quenched at its source.

As an example actual experiments performed with a still of the kind illustrated in Fig. 4 gave the following results with sea water. In Table I the values for K^1 in the last column represent the total heat transfer through the evaporating and condensing films and the heat transfer barrier itself.

TABLE I

Rate of Rotation of Barrier	Pressure lbs. inch² above atmos.	Differential per cent	Distillate per min. per ft.² barrier	Temp. Diff. Evap. & Condense	BTU Transferred ft.² per hr.	K^1= BTU/ft.² hr./1° F.
500 RPM	2.17	14.7	60 cc.	6.0	7700	1280
500 RPM	1.45	9.8	40 cc.	3.8	4780	1260
1000 RPM	2.42	16.5	145 cc.	6.7	18550	1980

The figures for K^1 are thus seen to be better than the very best hitherto known in steam boiler and condenser practice, and the temperature differentials are lower than reported in existing compression distillation of sea water at reasonable throughputs.

The compression still, according to my invention, is particularly useful in connection with the purification of water, such as brackish water and sea water. There are, however, many other impure liquids which [illegible] distilled [illegible] cost of heat for distillation is a major item, and I contemplate the use of the various forms of still embodying my invention for the distillation generally of organic substances, including particularly petroleum distillates, alcohols, ethers and esters, which are manufactured and handled in large quantities by industry. I do not, however, limit the use of my invention to these substances and contemplate purification of any mixtures of liquid material where the use of extended surfaces lowers thermal exposure and where substantial conservation of vapors is important.

It is to be understood that the vapor should be compressed to an extent sufficient so that it will condense at a temperature on the condensing surface just above that at which vapor is evolved from the film of distilland on the opposite side of the barrier and preferably [illegible] vapor [illegible] compressed to create a pressure differential of less than 20 [illegible] of the absolute saturated vapor pressure of the distilland at the temperature of the film thereof.

What I claim is:—

1. A compression still comprising at least one rotary heat exchange and phase separation barrier of high thermal conductivity having integral radially extending evaporating

and condensing surfaces disposed in heat exchange relationship, a feed pipe for continuously supplying distilland to said evaporating surface, radially inwardly from the outer periphery thereof, at a rate in excess of that required to wet said evaporating surface, means for rotating said barrier at a speed producing centrifugal force sufficient to continuously spread and flow and maintain said distilland on said evaporating surface in a film substantially thinner than that attainable by gravitational flow with the same throughput, means for collecting residue centrifugally discharged from said evaporating surface, means for compressing vapor evolved from the evaporating surface, and means for directing said compressed vapor into contact with the condensing surface upon which surface the vapor condenses and the condensate is maintained in a film substantially thinner than that attainable by gravitational flow with the same throughput, said condensate being removed from the condensing surface through rotation of said barrier.

2. A compression still according to Claim 1 wherein said means for collecting residue centrifugally discharged from the evaporating surface comprises an annular trough.

3. A compression still according to Claim 2 wherein said annular trough is rotatable with said evaporating surface and the residue collecting means comprises a conduit having an end facing upstream and projecting into said annular trough.

4. A compression still according to Claim 1, 2 or 3 wherein said means for rotating said barrier produces centrifugal force at least ten times the force of gravity.

5. A compression still according to any of the preceding claims wherein the means for compressing vapor evolved from the evaporating surface comprises a series of blades distributed about the periphery of said barrier and secured for rotation therewith.

6. A compression still according to any of Claims 1 to 4 wherein the compressor means constitutes a frame or disc carrying fan blades located thereon, said frame or disc being mounted substantially adjacent to and concentric with said barrier.

7. A compression still according to any of the preceding claims in which said barrier comprises a conical member.

8. A compression still according to any of Claims 1 to 5 wherein said rotary barrier comprises a disc.

9. A compression still according to any of Claims 1 to 4 wherein said rotary barrier is in the form of paired conical members [illegible]ing a compartment therebetween.

10. A compression still according to any of Claims 1 to 4 in which said rotary barrier comprises a corrugated tubular member.

11. A compression still according to Claim 1, 2, 3 or 4, wherein said rotary barrier is in the form of a hollow member, the inside of which forms evaporating surface and the outside of which forms said condensing surface.

12. A compression still according to Claim 1, 2, 3 or 4,wherein the distilland discharged by said feed pipe is utilized to effect the rotation of said barrier.

13. A compression still according to any of the preceding claims, wherein the vapor is compressed by the vapour compressor means so as to create a pressure differential of less than twenty per cent of the absolute saturated vapor pressure of the distilland at the temperature thereof.

14. A compression still according to Claim 1 including provisions for centrifuging said vapor as it evolves with respect to such film of distilland.

15. A compression still according to any of the preceding claims wherein said evaporating surface is so disposed with respect to the axis of rotation of said barrier that liquid on said evaporating surface will be forced toward said surface upon rotation of said barrier.

16. That method of continuous distillation which comprises applying centrifugal force of a magnitude many times greater than the force of gravity to distilland so as to continuously distribute and flow and maintain distilland on the evaporating surface of a heat exchanger in a film substantially thinner than can be secured by a flow of such distilland of the same throughput on the same surface flowing under the influence of a force of the order of gravity alone, continuously evolving vapour from said flowing film and separating the residue therefrom, collecting said residue out of contact with said flowing film, withdrawing and compressing said vapor and contacting such compressed vapor with a condensing surface on the opposite side of said heat exchanger so as to condense said vapor thereon, whereby heat is transferred to said evaporating surface and thence to said film of distilland to effect the evolution of vapor therefrom, and separating condensate from said condensing surface as it condenses thereon so as to prevent the accumulation of such condensate on said condensing surface.

17. That method according to Claim 16, wherein centrifugal force is applied to said condensate to separate said condensate from said condensing surface as it condenses thereon, so as to prevent the accumulation of said condensate on said condensing surface in a film thicker than that of said flowing film of distilland.

18. That method according to Claim 16 or 17 wherein the vapor is compressed to create a pressure differential of less than 20% of the absolute saturated vapor pressure of the distilland at the temperature thereof.

19. That method according to Claim 16, 17 or 18 including the step of centrifuging said

vapor as it evolves with respect to said evaporating face.

20. That method according to any of Claims 16—19, wherein said distilland is distributed and flowed in a film no thicker than a flow of such distilland of the same throughput impelled by a force at least ten times gravity on a surface the same as said evaporating surface.

21. That method according to any of Claims 16 to 20, wherein centrifugal force is applied to said distilland so as to force said distilland against said evaporating surface.

22. That method according to any of Claims 16 to 21, wherein centrifugal force is applied to said distilland and to said condensate by the rotation of said heat exchanger.

23. A compression still constructed and adapted to operate substantially as herein described with particular reference to the embodiments shown in the accompanying drawings.

24. A method of continuous distillation substantially as herein described.

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757,085 COMPLETE SPECIFICATION

3 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEET 1

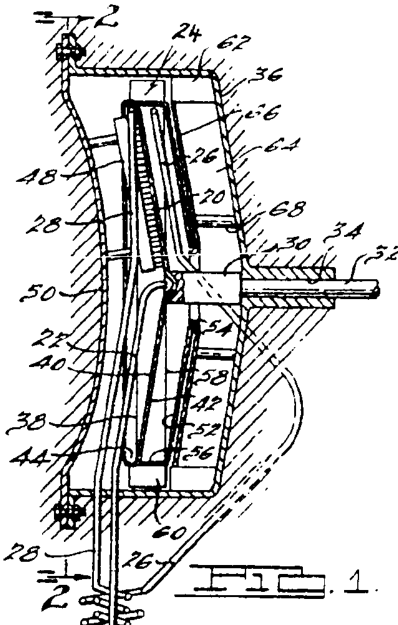

FIG. 1.

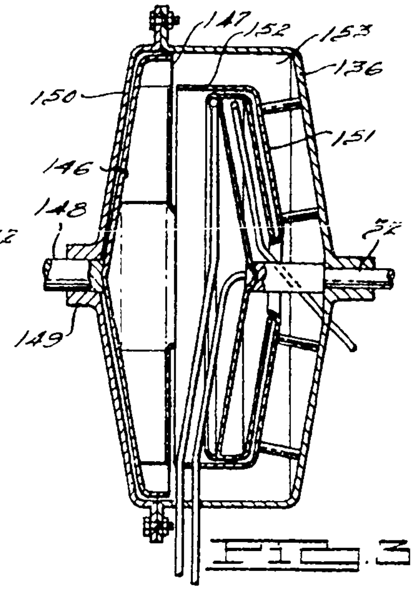

FIG. 3.

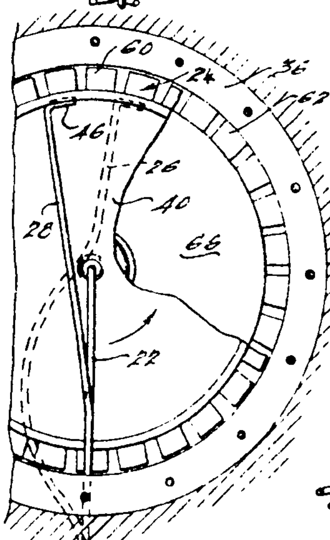

FIG. 2.

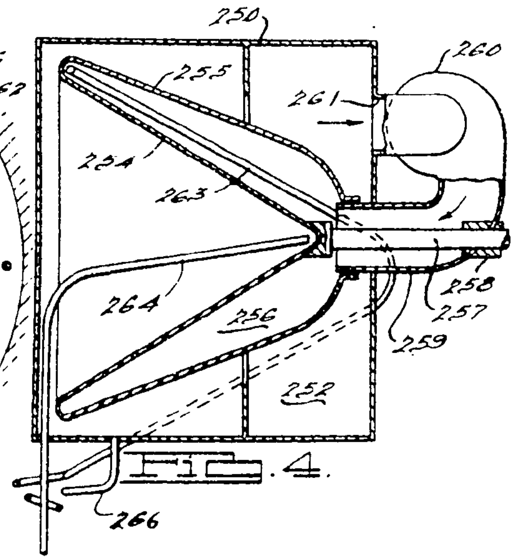

FIG. 4.

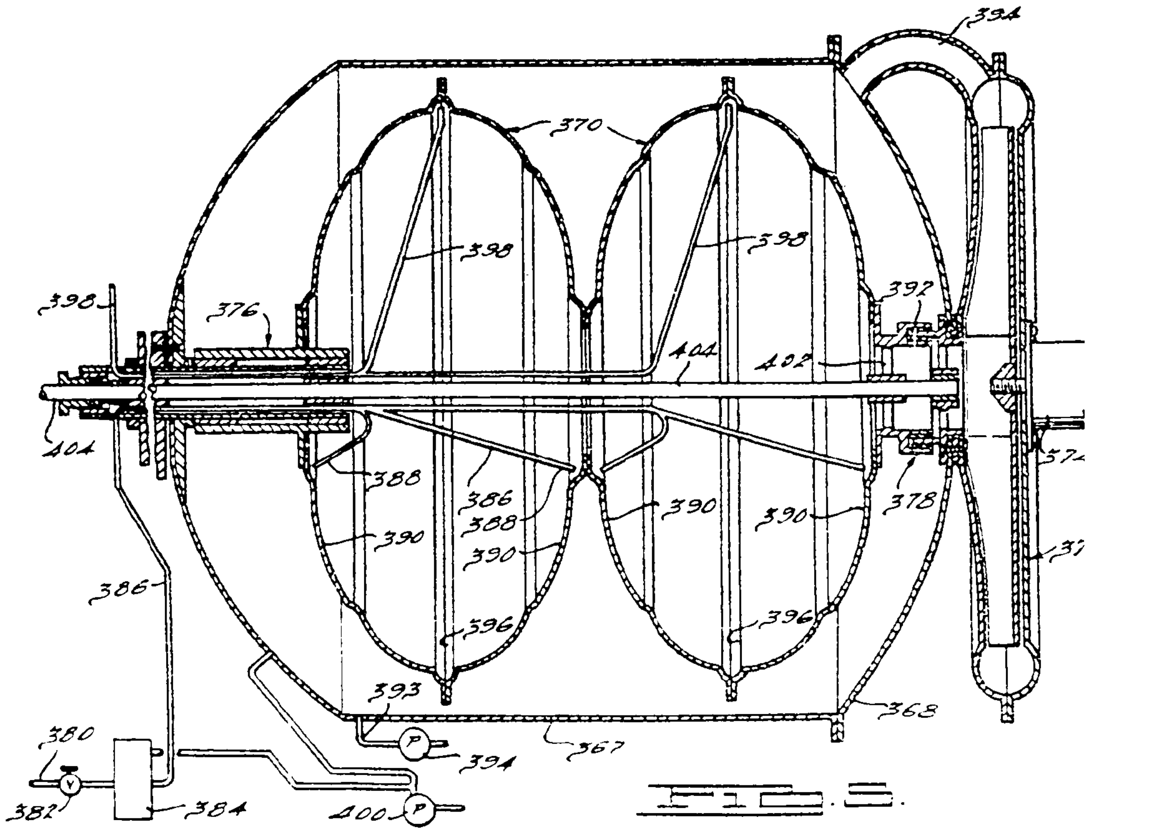

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FIG. 5.

757,085 COMPLETE SPECIFICATION
3 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEETS 2 & 3

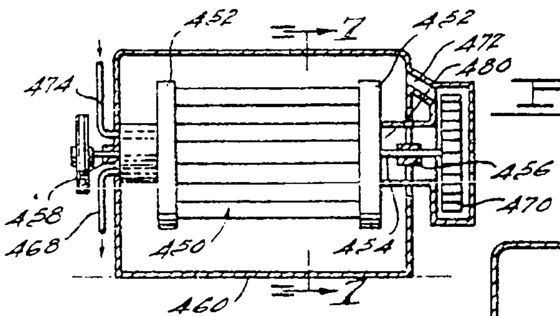
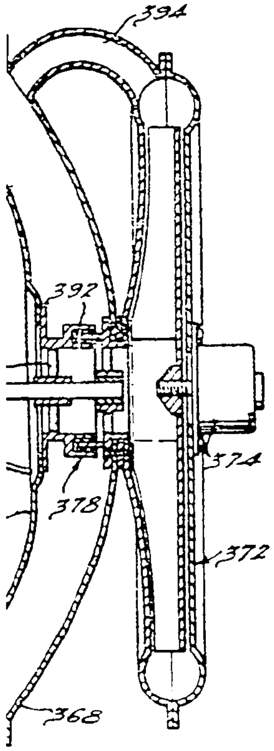


FIG. 6.



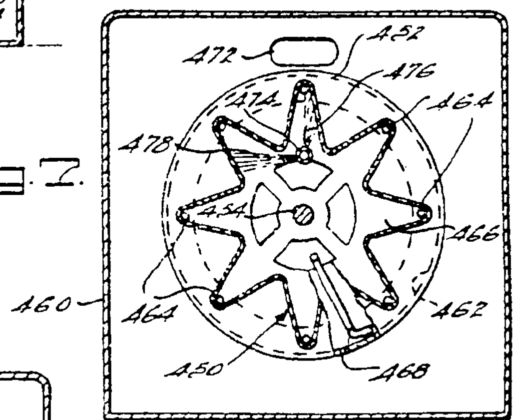


FIG. 7.

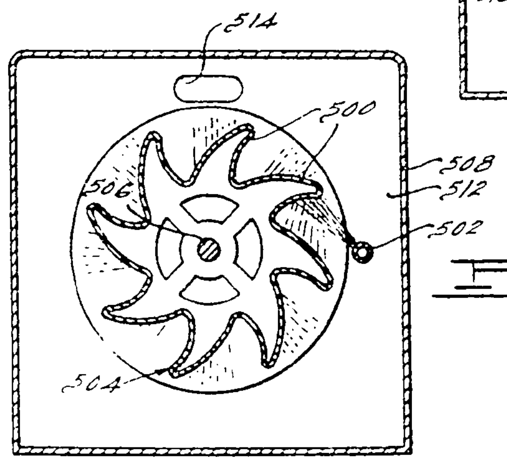


FIG. 9.

5.

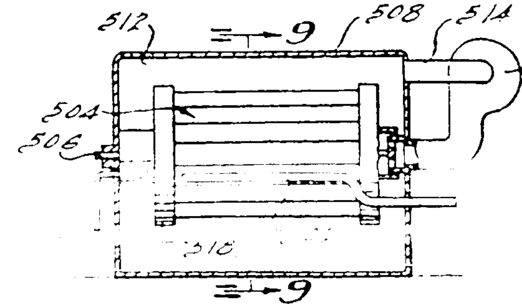


FIG. 8.

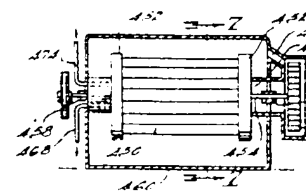


FIG. 6.

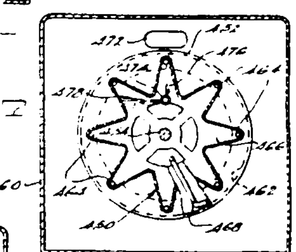


FIG. 7

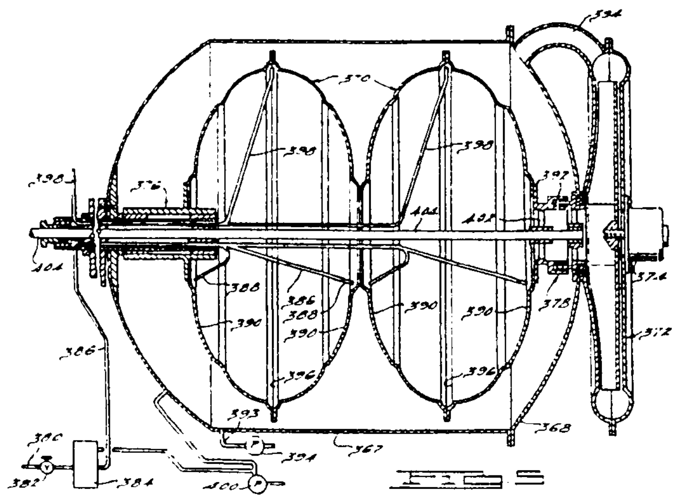


FIG. 5

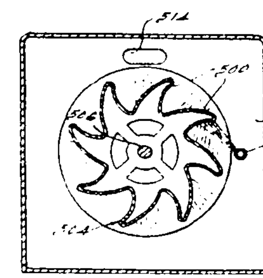


FIG. 9.

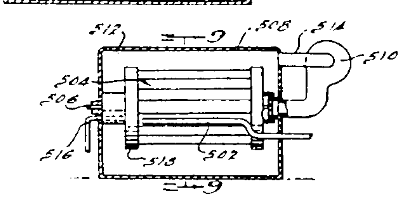


FIG. 8.